

Claims

suba1) 1. A method for processing frames of streaming data through modules in a digital computer, comprising:

constructing a pipe as a connected group of multiple ones of the modules, at least one of the modules being a restructuring module;

allocating composite frames having predefined subframes;

transporting the streaming data through different ones of the modules in the group in different ones of the subframes;

restructuring the data among at least some of the subframes in the restructuring module.

2. A computer readable medium bearing instructions and data for causing a digital computer to execute the method of claim 1.

3. The method of claim 1 where the composite frame is a physical frame in a memory.

4. The method of claim 3 where the subframes are virtual frames defined in the same memory as the physical frame.

5. The method of claim 1 further comprising assigning an allocator for the composite frames to one of the modules in the pipe.

suba2) 6. The method of claim 5 where the allocator is assigned to the farthest upstream restructuring module in the pipe.

7. The method of claim 5 where the allocator is assigned to the farthest downstream restructuring module in the pipe.

8. The method of claim 1 further comprising constructing a frame nesting tree specifying how the data is to be restructured in the restructuring module.

9. The method of claim 1 further comprising:

repeating the above steps for further pipes including further modules in the computer;

joining the pipes together into a graph.

10. The method of claim 1 where transporting the streaming data includes issuing a control transaction to the restructuring module only when all of the subframes processed by that module become available.

11. A method for processing frames of streaming data through multiple modules disposed in a pipe including at least one restructuring module in a digital computer, comprising:

allocating a composite frame having multiple subframes;

performing operations upon the subframes in any of the modules sourcing data to the restructuring module;

after completion of the operations for all of the subframes sourcing data to the restructuring module, issuing a control transaction to the restructuring module;

performing operations upon the subframes sourced to the restructuring module in response to the control transaction.

12. A computer readable medium bearing instructions and data for causing a digital computer to execute the method of claim 11.

13. The method of claim 11 where allocating the composite frame includes constructing a frame control table having an entry for each module in the pipe and a flag for each of the modules indicating whether a particular module has completed an operation upon the frame.

14. The method of claim 13 further comprising setting one of the flags whenever a module has completed an operation upon a frame.

14/ 10/
15. The method of claim 11 further including constructing an offset table specifying the structure of the subframes within the composite frame.

15/ 10/
16. The method of claim 11 further comprising constructing a pipe control table specifying the structure of the modules in the pipe.

14/ 15/
17. The method of claim 16 where the pipe control table has an entry for at least some of the modules in the pipe, and where each entry specifies which other module or modules source data to one of the modules in the pipe.

17/ 15/
18. The method of claim 16 where the pipe control table has an entry for each module in the pipe that sources data from outside the pipe.

sub 4) 19. The method of claim 11 further comprising repeating the above steps overlapped in time such that a plurality of composite frames circulate within the pipe concurrently.

19/ 18/
20. The method of claim 19 further comprising constructing a separate frame control table for each of the composite frames.

21. A method for processing frames of streaming data through modules including multiple restructuring modules in a digital computer, comprising:

constructing a pipe as a connected group of the modules including the restructuring modules;

assigning a single allocator to one of the modules;

allocating composite frames having predefined subframes associated with respective ones of the restructuring modules;

transporting the streaming data through different ones of the modules in the group in different ones of the subframes;

restructuring the data among the subframes in the restructuring modules.

22. A computer readable medium bearing instructions and data for causing a digital computer to execute the method of claim 21.

22 23. The method of claim ²⁰21 further comprising constructing a frame nesting tree specifying how the data is restructured by the restructuring module.

23 24. The method of claim ²⁰21 further comprising collecting a constant-offset flag for each module.

24 25. The method of claim ²³24 further comprising collecting an offset value for any module whose constant-flag is set.

25 26. The method of claim ²³24 further comprising constructing an offset table specifying relationships of the subframes to the composite frame.

²⁶
~~27~~. The method of claim ²³~~24~~ further comprising specifying memory sizes for each of the subframes within the composite frame.

²⁷
~~28~~. The method of claim ²⁰~~21~~ where a plurality of the restructuring modules are of a single type in a cascade in the pipe.

²⁷
~~29~~. The method of claim ²⁷~~28~~ where the allocator is assigned to a particular module in response to the type of cascaded modules.

²⁹
~~30~~. The method of claim ²⁷~~28~~ where the plurality of cascaded modules are mixers, and where the allocator is assigned to a downstream one of the cascaded mixers.

³⁰
~~31~~. The method of claim ²⁷~~28~~ where the plurality of cascaded modules are splitters, and where the allocator is assigned to an upstream one of the cascaded splitters.

³¹
~~32~~. The method of claim ²⁰~~21~~ where transporting the streaming data includes issuing control transactions to the restructuring modules only when all of the subframes processed by respective ones of the modules become available.

sub 33
33. A method for processing frames of streaming data through modules including multiple restructuring modules connected in a pipe in a digital computer, comprising:

allocating a composite frame having multiple subframes for different ones of the restructuring modules;

performing data-sourcing operations upon certain of the subframes in source ones of the modules;

when each one of the data-sourcing operations has completed, determining whether one of the restructuring modules has all of the subframes required for it to perform an operation;

if so, issuing a control transaction to the one restructuring module;

performing an operation in the one restructuring modules after receiving a control transaction.

34. A computer readable medium bearing instructions and data for causing a digital computer to execute the method of claim 33.

³⁴
~~35~~. The method of claim ³²~~33~~ where the source ones of the modules are those receiving data from outside the pipe.

³⁵
~~36~~. The method of claim ³²~~33~~ where a plurality of the restructuring modules are mixers.

³⁶
~~37~~. The method of claim ³⁵~~36~~ where a plurality of the mixers are cascaded in the pipe.

³⁷
~~38~~. The method of claim ³²~~33~~ further comprising:

when each one of the data-sourcing operations has completed, determining whether others of the restructuring modules have all of the subframes required for them to perform operations;

if so, issuing control transactions to the other restructuring modules;

performing operations in the other restructuring modules after receiving the control transactions.

³⁸
~~39~~. The method of claim 33 further comprising:

storing a separate completion flag for each of the modules in the pipe;

setting one of the completion flags when a corresponding one of the modules has completed an operation upon the frame.

39
40. The method of claim 39 where the determining step comprises:

reading a table listing all of the other modules that source data to the one restructuring module;

determining whether a completion flag for all of the other modules has been set.

41. The method of claim 33 further comprising repeating the above steps overlapped in time such that a plurality of composite frames circulate within the pipe concurrently.

42. The method of claim 41 further comprising constructing a separate frame control table for each of the composite frames.

43. A data structure for processing streaming data through multiple restructuring processing modules in a graph, comprising:

a single composite frame physically allocated in a memory;

a plurality of virtual subframes allocated within the composite frame.

44. The structure of claim 43 where different ones of the subframes contain different types of data.

45. The structure of claim 44 where one type of data is video data.

46. The structure of claim 44 where another type of data is audio data.

55. The structure of claim 54 where the frame control table includes a column for holding flags indicating that each of the modules has completed processing the frame.

56. The structure of claim 53 further comprising a separate frame control table for each frame circulating in the pipe at a particular time.

57. A computer system for processing streaming data, comprising:

a plurality of modules for processing the streaming data, at least some of which are restructuring;

a plurality of memory managers for allocating composite frames containing subframes for containing streaming data;

a flow manager for constructing a graph having at least one pipe including a plurality of the restructuring modules, and for assigning one of the memory managers to the pipe.

58. The system of claim 57 further comprising a memory for storing the composite frames.

59. The system of claim 58 where the subframes are allocated within the composite frames in the memory.

60. The system of claim 58 further including a processor.

61. The system of claim 60 where the processor implements one or more of the restructuring modules.

47
62. The system of claim 60 further including an input/output system.

48 47
63. The system of claim 62 where the input/output system implements one or more of the modules.

49 42
64. The system of claim 57 further comprising a pipe manager for constructing representations of the structures of the composite frames.

50 49
65. The system of claim 64 where one of the representations specifies locations of the subframes with respect to the composite frame.

51 49
66. The system of claim 64 where one of the representations specifies relationships of the modules within the pipe.

52 42
67. The system of claim 57 further including a control manager for transporting the streaming data through the modules in various ones of the subframes.

68. The system of claim 67 where the control manager issues a control transaction to one of the restructuring module for initiating processing of a subframe therein only when all of the subframes processed by that module become available.

69. A computer system for processing streaming data, comprising:

a plurality of modules disposed in a pipe for processing the streaming data, at least some of the modules being restructuring;

a plurality of memory managers for allocating composite frames containing subframes for containing streaming data, different ones of the subframes being associated with different ones of the modules;

a control manager for issuing control transactions for initiating processing operations in the modules.

⁵⁵
70. The system of claim ⁵⁴69 where the control manager issues one of the control transactions to a particular module only when certain of the subframes associated with that module become available.

⁵⁶
71. The system of claim ⁵⁵70 where the certain subframes include all of the subframes that source data to the particular module.

⁵⁷
72. The system of claim ⁵⁴69 where certain of the modules receive data from outside the pipe.

⁵⁸
73. The system of claim ⁵⁷72 where the control manager issues a control transaction to the certain modules when one of the composite frames has been allocated.

⁵⁹
74. The system of claim ⁵⁴69 where at least some of the restructuring modules are mixers for combining multiple ones of the subframes.

⁶⁰
75. The system of claim ⁵⁹74 where a plurality of the mixers are cascaded in the pipe.

⁶¹
76. The system of claim ⁶⁰75 where the control manager issues one of the control transactions to any of the mixers only when all of the subframes combined by that mixer become available.

^{sub 13}
77. The system of claim 69 further comprising a memory for storing the composite frames.

78. The system of claim 77 where the processor implementing one or more of the restructuring modules.

⁶⁴79. The system of claim ⁶³78 further including an input/output system implementing one or more of the modules.

80. A computer readable medium bearing instructions and data for causing a digital computer to execute a method for processing frames of streaming data through modules in a digital computer, the method comprising:

constructing a pipe as a connected group of multiple ones of the modules, at least one of the modules being restructuring;

allocating composite frames having predefined subframes;

transporting the streaming data through different ones of the modules in the group in different ones of the subframes;

restructuring the data among at least some of the subframes in the restructuring module.

81. A computer readable medium bearing instructions and data for causing a digital computer to execute a method for processing frames of streaming data through multiple modules disposed in a pipe including at least one restructuring module in a digital computer, the method comprising:

allocating a composite frame having multiple subframes;

performing operations upon the subframes in any of the modules sourcing data to the restructuring module;

after completion of the operations for all of the subframes sourcing data to the restructuring module, issuing a control transaction to the restructuring module;

47. The structure of claim 43 further comprising an offset table for locating the subframes with respect to the composite frame.

48. The structure of claim 47 where the offset table includes an entry for each of the subframes and a column for specifying the locations of the subframes within the composite frame.

49. The structure of claim 43 further comprising a pipe control table representing the structure of a pipe of modules for processing streaming data in the data structure.

50. The structure of claim 49 where the pipe control table includes an entry for each of the modules in the pipe.

51. The structure of claim 50 where the pipe control table includes a source column for listing other modules that source data to the modules in each of the entries.

52. The structure of claim 50 where the pipe control table includes a start section listing those modules that source data from outside the pipe.

53. The structure of claim 43 further comprising a frame control table for tracking the status of the frame with respect to the processing modules.

54. The structure of claim 53 where the frame control table includes an entry for each of the modules in the pipe.

66253-5501e60

performing operations upon the subframes sourced to the restructuring module in response to the control transaction.

6622133 36393720